



ASSIGNING DISTANCES AND CONVECTIVE HEAT TRANSFER COEFFICIENTS for U_{fr} and U_{eg} CALCULATIONS ACCORDING TO NFRC-100

Introduction

[case1.bsc](#), [case2.bsc](#), [case3.bsc](#)

This document clarifies how frame sections are set up for calculation of the equivalent U-values according to NFRC-100. NFRC-100 specifies the following equations from ISO 15099 for deriving the equivalent U-values for 1) the frame and 2) the edge of glazing.

$$U_{fr} = \frac{\phi_{fr}}{l_f \cdot (T_i - T_e)} \quad (1)$$

$$U_{eg} = \frac{\phi_{eg}}{l_{eg} \cdot (T_i - T_e)} \quad (2)$$

in which l_f is the projected length of frame area and l_{eg} is the length of the edge of glass area and is equal to 63.5 mm. These lengths are measured on the internal side. The quantities Φ_{fr} and Φ_{eg} are the heat flows through the frame area and the edge-glass area respectively, including the effect of glass and spacer.

NFRC-100 defines the concept 'sightline' as the line formed by the outermost opaque member (such as a frame, sash, spacer, divider, or shading system), whether located on the interior, exterior, or within the glazing system cavity, in a plane perpendicular to the surface.

When assigning the distances l_f and l_{eg} and heat flow rates (Φ_{fr} and Φ_{eg}), the concept of a 'sightline' plays a crucial role.

In the context of U-value calculations, it is important to note different types of boundary conditions applied to the frame area and the glass areas. For both, NFRC 100 specifies view-factor-based infrared radiation on the interior surface (BC_SKY). However, the convective surface heat transfer coefficients differ. For the frame area, NFRC 100 prescribes a fixed convective coefficient based on the frame type (see table below (or Table 4.2 in NFRC 100)). In contrast, for the glass area, a temperature-difference-dependent convective coefficient must be used, as specified in ISO 15099.

Boundary Condition Radiation model		Convective Film Coefficient (Tilt = 90°) [W/m²K]
NFRC 100-2010 Exterior	*	26.00
Interior Aluminum Frame (convection only)	**	3.29
Interior Thermally Broken Frame (convection only)	**	3.00
Interior Thermally Improved Frame (convection only)	**	3.12
Interior Wood/Vinyl Frame (convection only)	**	2.44
Interior Glazing System boundary condition	***	hc=f(ΔT)

* Blackbody (type = BC_SIMPL, standard = ISO 15099)

** Automatic Enclosure model (type = BC_SKY, standard = NIHIL)

*** Automatic Enclosure model (type = BC_SKY, standard = ISO 15099)

In summary there are 3 important aspects to consider in the calculation of U_{fr} and U_{eg} in BISCO, for which the first two depend on the position of the 'sightline':

- Length of frame l_{fr} and length of edge of glass zone l_{eg} , defined in BISCO with 'distances'.
- Heat flow through frame Φ_{fr} and through edge of glass zone Φ_{eg} defined via boundary conditions colours.
- Different convective surface coefficients at frame and glass defined via boundary condition colours (not necessarily the same as in the previous point).

This document explains the settings in BISCO for the three possible situations where the sightline can be located:

- Sightline at interface opaque-transparent (case 1)
- Spacer bar outside frame (case 2)
- Frame with protruding part (case 3)

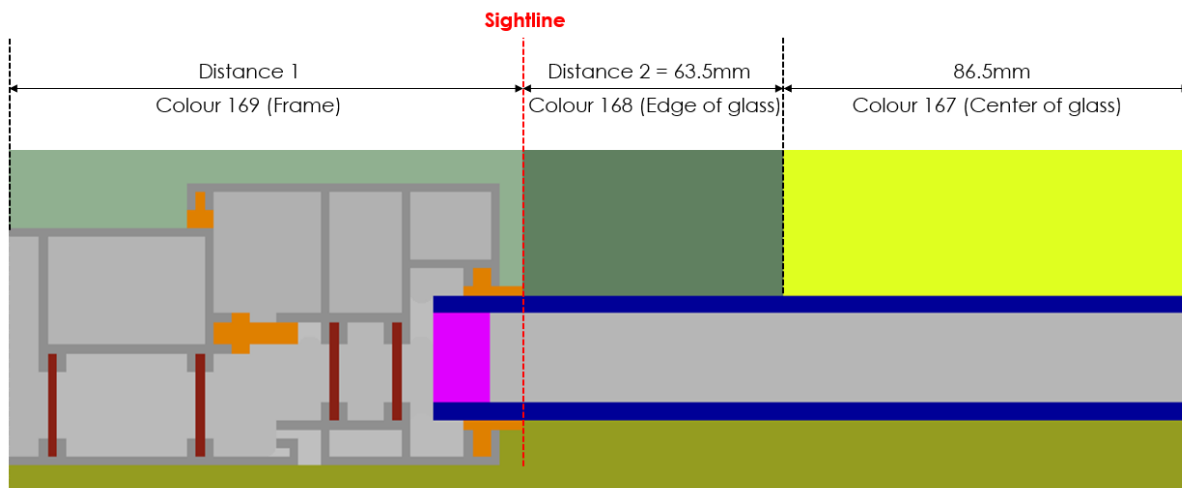
1. Case 1: Sightline at interface opaque-transparent

[case1.bsc](#)

In the configuration below, the most right opaque element in the assembly is EPDM. According to the definition of NFRC-100, the sightline will be on the interface between EPDM and glass. Hence all elements on the lefthand side of this sightline should be considered a part of the frame. The edge of glass zone is located on the right side and ends 63.5 mm from the sightline.

This configuration is most straightforward and does not require any manual adjustment of the boundary condition colours or distances by the user when the automatic preparation procedure in BISCO (*Bitmap → NFRC 100/500 Preparation...*).

The bitmap below illustrates this situation with an example.



In the calculation of U_{fr} and U_{eg} (see equation (1) and (2) above) l_{fr} = Distance 1 and l_{eg} = Distance 2. Also, it can be seen from the bitmap that each distance only has one boundary condition colour where Φ_{fr} is the heat flow coming into the frame (colour 169) and Φ_{eg} is the heat flow coming into the edge of glazing (colour 168).

Initially, the distances must be assigned through the **Distances window**,

No.	Mode	Dir.	Extent	State	Length [pix.]	Length [m]	X1	Y1	X2	Y2	U [W/m²K]	Enforced U [W/m²K]
1	LOCKED	X	MAX	NORMAL	1151	0.1151	0	0	1150	0		
2	LOCKED	X	MAX	NORMAL	635	0.0635	1150	0	1784	0		
3	LOCKED	X	MAX	NORMAL	865	0.0865	1785	32	2649	32		

Once assigned, to set up the output of U_{fr} , U_{eg} and U_{cg} , *Edit* → *Derived Thermal Properties...*

☒ Equivalent thermal transmittance (U) - based on incoming heat flow from boundary condition

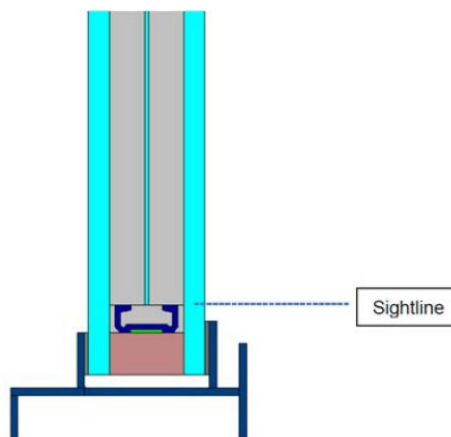
Element 1	Element 2	Element 3
Subscript: fr	☒ Element 2 Subscript: eg	☒ Element 3 Subscript: cg
Width along distance no.: 1	Width along distance no.: 2	Width along distance no.: 3
☐ Add width distance no.: 2	☐ Add width distance no.: 3	☐ Add width distance no.: 3
Heat flow BC colour no.: 169	Heat flow BC colour no.: 168	Heat flow BC colour no.: 167
☐ Add BC colour no.: 182	☐ Add BC colour no.: 182	☐ Add BC colour no.: 182

OK Cancel

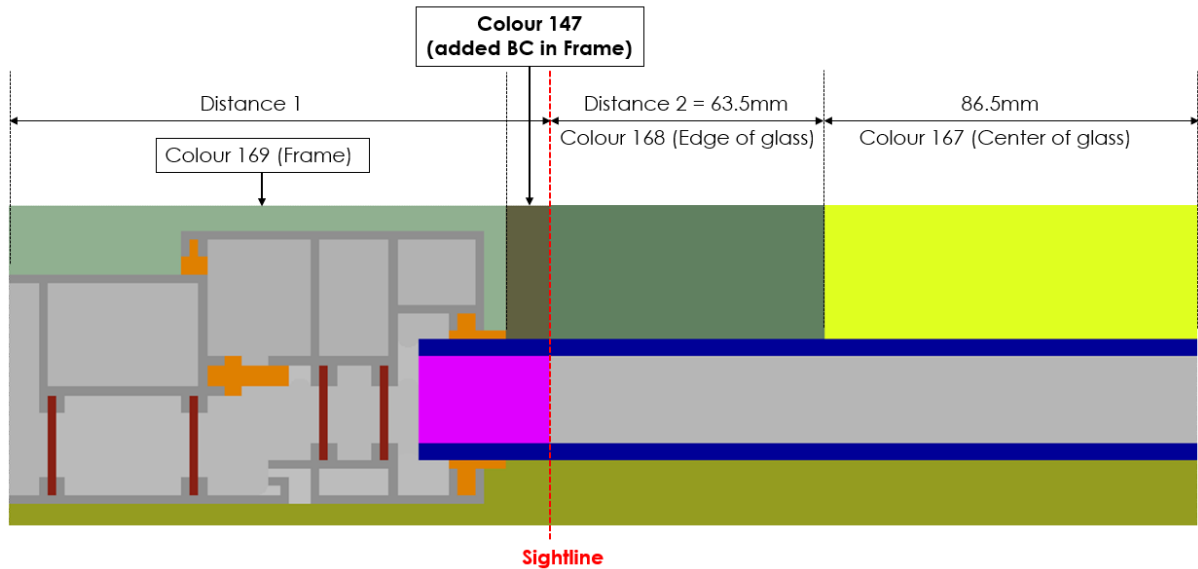
2. Case 2 : Spacer bar outside frame

[case2.bsc](#)

When the glazing spacer bar is the outermost opaque material, the sightline is created at its interface with the glass. The figure below - taken from the NFRC simulation manual – illustrates the position of the sightline. Consequently, the area below the sightline has both glass and frame surfaces, for which different convective surface coefficients hold. However, the heat flow below the sightline is accounted to the frame.



This is illustrated below using the same example, but with the spacer bar now extending beyond the EPDM. In this case, it is necessary to manually assign an additional boundary condition colour (in this example, colour 147) to the interior glazed area between the sightline and the frame. This additional colour allows to assign a different convective surface coefficient to the glazed surface in the frame zone (on lefthand side of the sightline).



Now in the calculation of the U_f (see equation (1) above), Φ_{fr} corresponds to the sum of the heat flow leaving boundary condition colours 169 and 147.

In addition, distances must be defined in the **Distances window**. Since Distance 1 involves two boundary condition colours, it must be assigned manually.

No.	Mode	Dir.	Extent	State	Length [pix.]	Length [m]	X1	Y1	X2	Y2	U [W/m²K]	Enforced U [W/m²K]
1	LOCKED	X	FREE	NORMAL	1253	0.1253	0	0	1252	0		
2	LOCKED	X	MAX	NORMAL	635	0.0635	1253	0	1887	0		
3	LOCKED	X	MAX	NORMAL	762	0.0762	1888	32	2649	32		

Once assigned, to set up the output of U_{fr} , U_{eg} and U_{cg} , *Edit* → *Derived Thermal Properties...*

☒ Equivalent thermal transmittance (U) - based on incoming heat flow from boundary condition

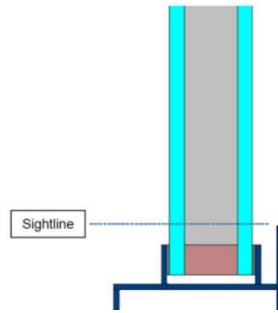
Element 1	Element 2	Element 3
Subscript: fr	Subscript: eg	Subscript: cg
Width along distance no.: 1	Width along distance no.: 2	Width along distance no.: 3
☐ Add width distance no.: 2	☐ Add width distance no.: 2	☐ Add width distance no.: 3
Heat flow BC colour no.: 169	Heat flow BC colour no.: 168	Heat flow BC colour no.: 167
☒ Add BC colour no.: 147	☐ Add BC colour no.: 182	☐ Add BC colour no.: 182

OK Cancel

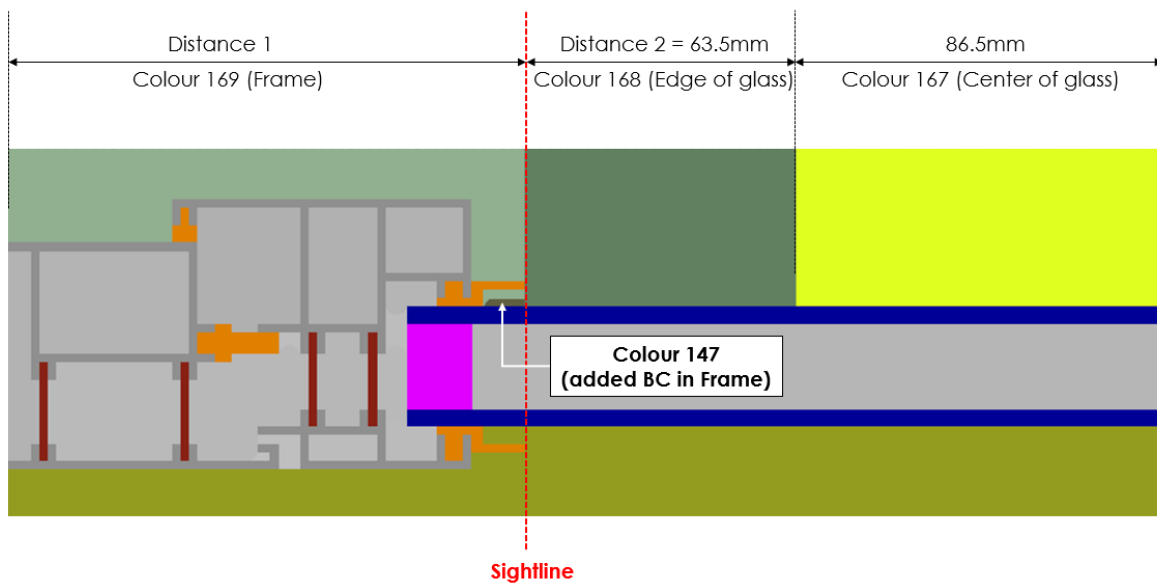
3. Case 3: Frame with protruding part

[case3.bsc](#)

Again the sightline is positioned at the highest opaque part, being the protruding part of the frame. The figure below – taken from the NFRC simulation manual - illustrates that below the sightline the boundary conditions touches both glass and frame material. This results in the same situation as described in the previous paragraph, where the heat flow corresponding to the frame consists of two boundary condition colours.



Using the same example, but now including a protruding part of EPDM, the figure below illustrates the manual assignment of an additional boundary condition colour (in this case, colour 147).



Again, in the calculation of the U_f (see equation (1) above), Φ_{fr} corresponds to the sum of the heat flow leaving boundary condition colours 169 and 147.

Distances												
No.	Mode	Dir.	Extent	State	Length [pix.]	Length [m]	X1	Y1	X2	Y2	U [W/m²K]	Enforced U [W/m²K]
1	LOCKED	X	MAX	NORMAL	1227	0.1227	0	0	1226	0		
2	LOCKED	X	MAX	NORMAL	635	0.0635	1226	0	1860	0		
3	LOCKED	X	MAX	NORMAL	789	0.0789	1861	6	2649	6		

Once assigned, to set up the output of U_{fr} , U_{eg} and U_{cg} , *Edit* → *Derived Thermal Properties...*

☒ Equivalent thermal transmittance (U) - based on incoming heat flow from boundary condition

Element 1 Subscript: fr Width along distance no.: 1 ☐ Add width distance no.: 2 Heat flow BC colour no.: 169 ☒ Add BC colour no.: 147	Element 2 ☒ Subscript: eg Width along distance no.: 2 ☐ Add width distance no.: 2 Heat flow BC colour no.: 168 ☐ Add BC colour no.: 182	Element 3 ☒ Subscript: cg Width along distance no.: 3 ☐ Add width distance no.: 3 Heat flow BC colour no.: 167 ☐ Add BC colour no.: 182
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